

# LOW-COST LoRa GATEWAY: A STEP-BY-STEP TUTORIAL



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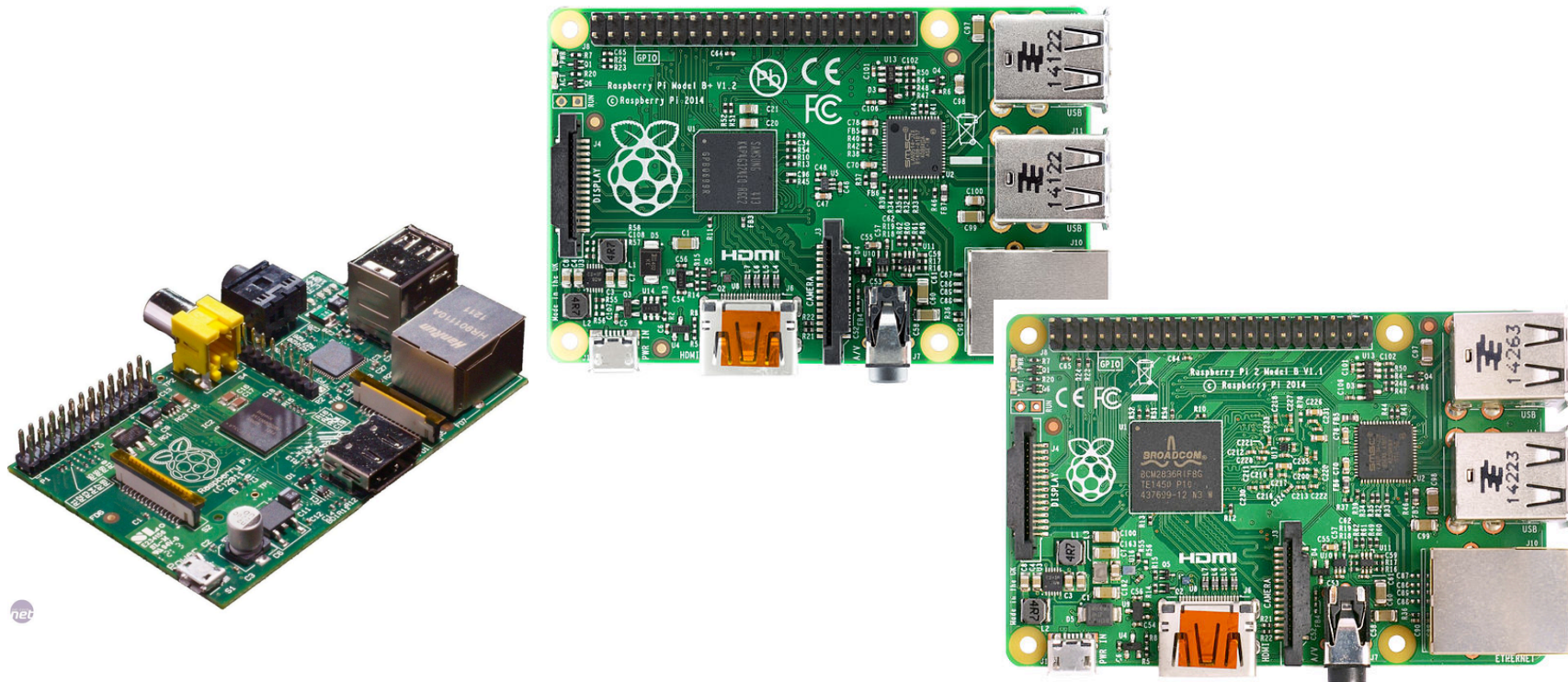
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- ❑ We will show how to build a low-cost LoRa gateway to collect data from end-devices
- ❑ The device part will be shown in a separate tutorial
- ❑ The hardware platform is a Raspberry PI. RPI v1 & 2 have been successfully tested
- ❑ Let's get started...

# ASSEMBLING THE HARDWARE



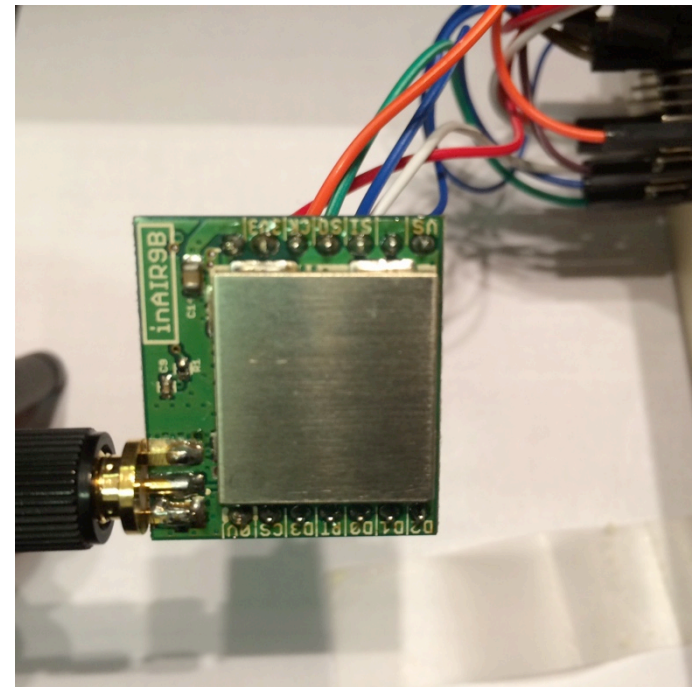
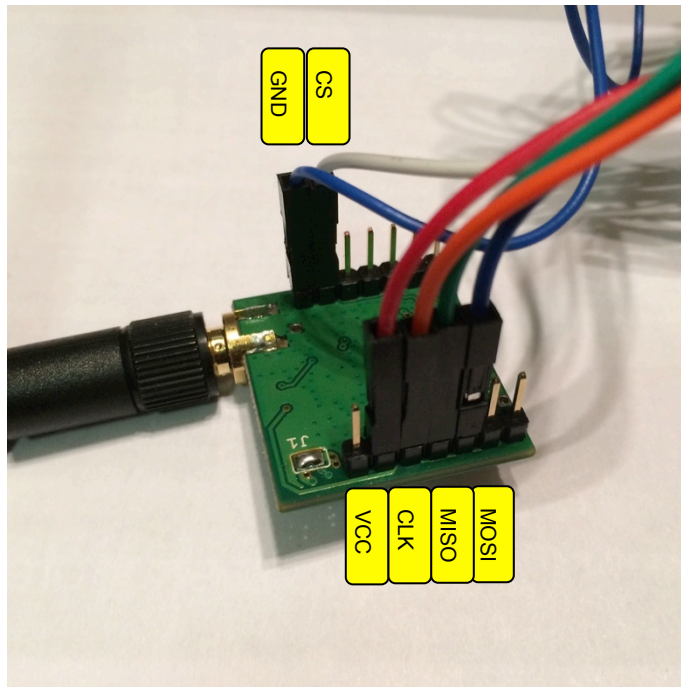
# GET THE RASPBERRY



You can use Raspberry 1 model B or B+ or Raspberry 2 model B. The most important usefull feature is the Ethernet interface for easy Internet connection. You can use WiFi to get Internet connection by adding a WiFi USB dongle.

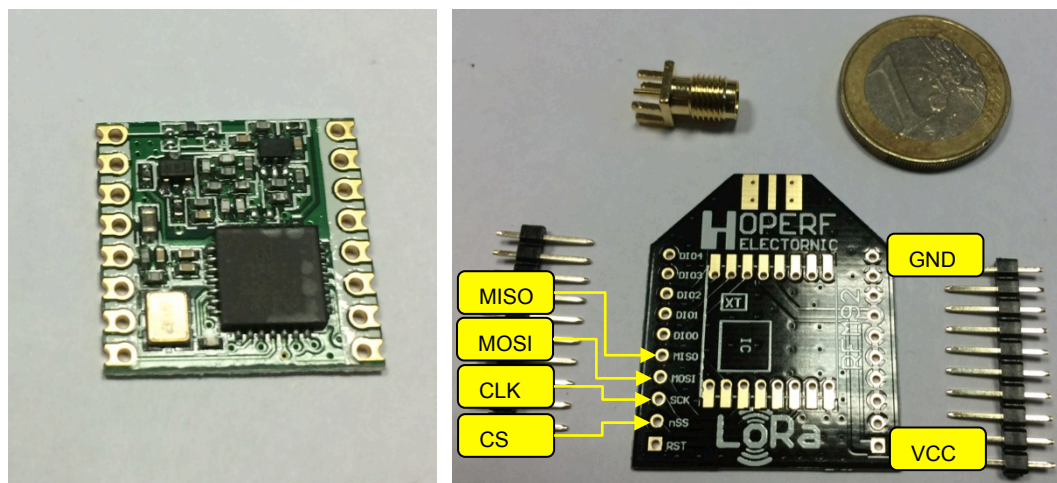


# NOW THE RADIO MODULE (1)



If you go for the inAir9 from Modtronix, then the header pins can come fully assembled. Take the 6mm header pins to have enough length to connect F/F breadboard cables (left). Connect the SPI pins with the F/F cables. Try to use different colors. I use the following colors: MOSI (blue), MISO (green), CS (white), CLK (orange). Then connect also the VCC (red) and the GND (black or any other dark color) of the radio board.

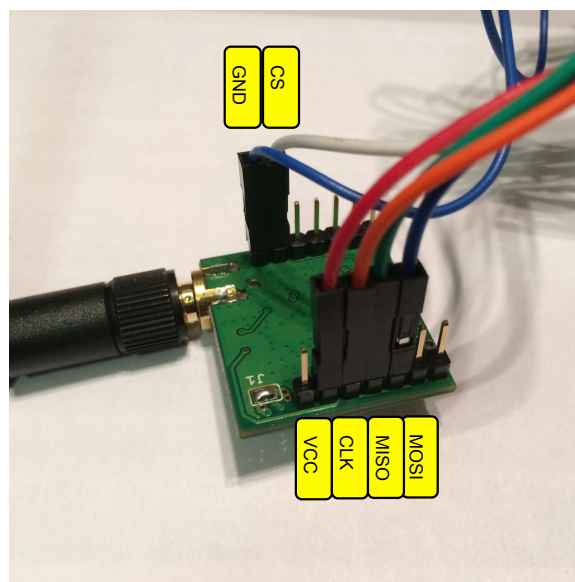
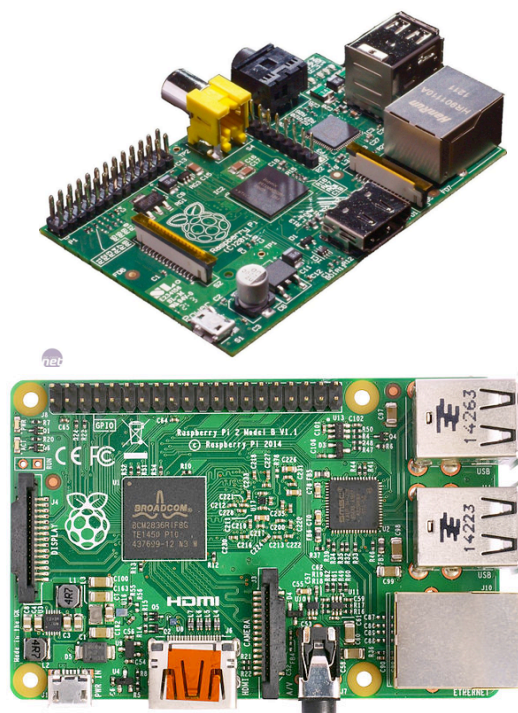
# NOW THE RADIO MODULE (2)



If you take the HopeRF RFM 92W/95W you will need the adaptor breakout and you have to go through some delicate but simple soldering tasks! It is not difficult but you have to be trained a bit before! Then, like for the inAir9, use F/F breadboard cable to connect the SPI pins, using different colors as explained previously.



# CONNECTING THE RADIO MODULE (1)

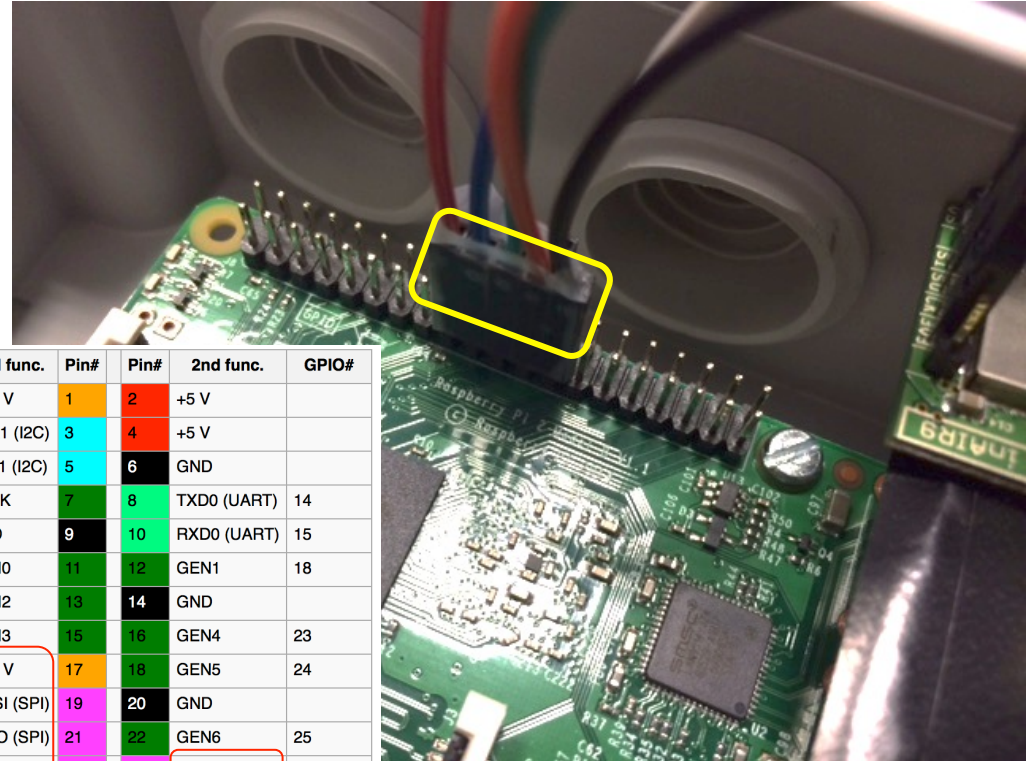
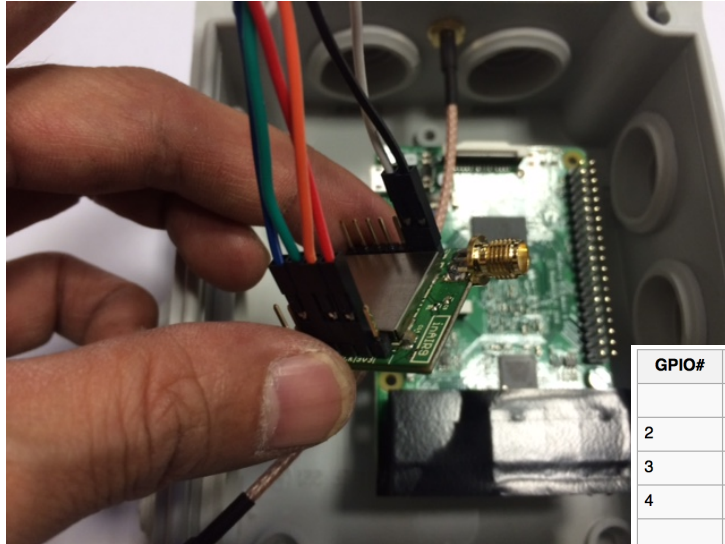


GPIO#	2nd func.	Pin#	Pin#	2nd func.	GPIO#
	+3.3 V	1	2	+5 V	
2	SDA1 (I2C)	3	4	+5 V	
3	SCL1 (I2C)	5	6	GND	
4	GCLK	7	8	TXD0 (UART)	14
	GND	9	10	RXD0 (UART)	15
17	GEN0	11	12	GEN1	18
27	GEN2	13	14	GND	
22	GEN3	15	16	GEN4	23
	+3.3 V	17	18	GEN5	24
10	MOSI (SPI)	19	20	GND	
9	MISO (SPI)	21	22	GEN6	25
11	SCLK (SPI)	23	24	CE0_N (SPI)	8
	GND	25	26	CE1_N (SPI)	7
(RPI 1 Models A and B stop here)					
EEPROM	ID_SD	27	28	ID_SC	EEPROM
5	N/A	29	30	GND	
6	N/A	31	32		12
13	N/A	33	34	GND	
19	N/A	35	36	N/A	16
26	N/A	37	38	Digital IN	20
	GND	39	40	Digital OUT	21

Depending on the model, you can have the « short » or the « long » GPIO interface. However, the SPI pins are at the same location therefore it does not change the way you connect the radio module if you take pin 1 as the reference. Connect the SPI pins (MOSI, MISO, CLK, CS) of the radio to the corresponding pins on the RPI. Note that CS goes to CE0\_N on the RPI.

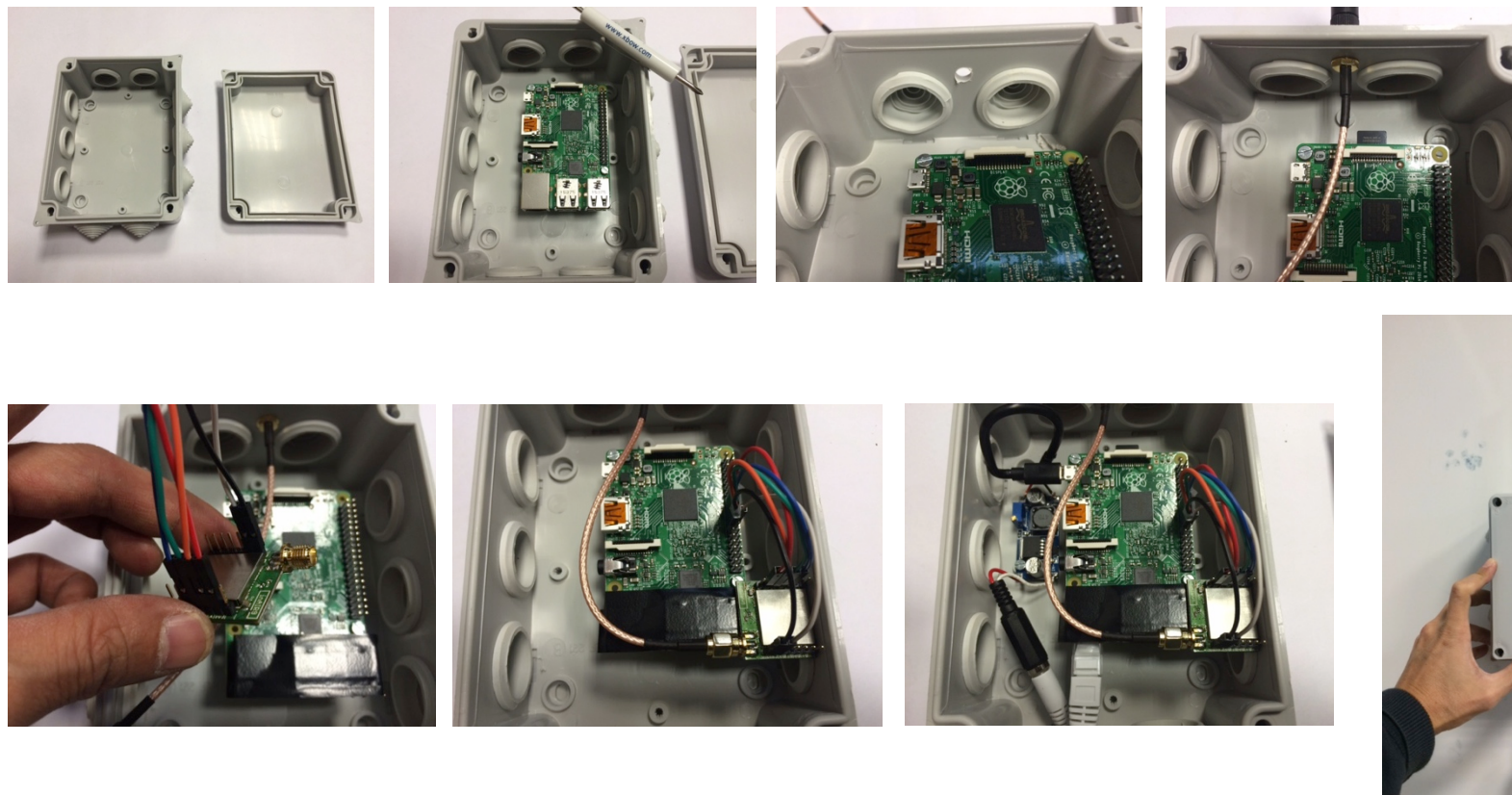


# CONNECTING THE RADIO MODULE (2)



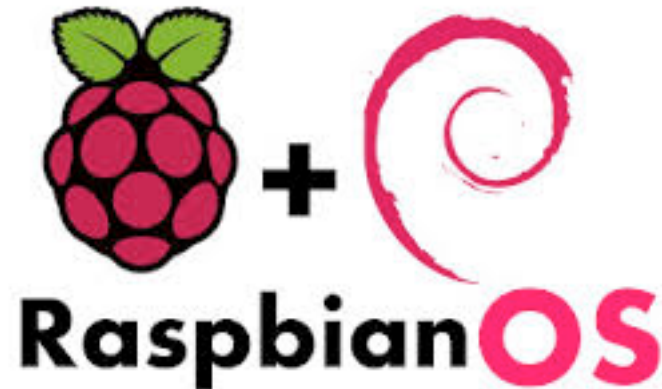
GPIO#	2nd func.	Pin#	Pin#	2nd func.	GPIO#
	+3.3 V	1	2	+5 V	
2	SDA1 (I2C)	3	4	+5 V	
3	SCL1 (I2C)	5	6	GND	
4	GCLK	7	8	TXD0 (UART)	14
	GND	9	10	RXD0 (UART)	15
17	GEN0	11	12	GEN1	18
27	GEN2	13	14	GND	
22	GEN3	15	16	GEN4	23
	+3.3 V	17	18	GEN5	24
10	MOSI (SPI)	19	20	GND	
9	MISO (SPI)	21	22	GEN6	25
11	SCLK (SPI)	23	24	CE0_N (SPI)	8
	GND	25	26	CE1_N (SPI)	7
(RPI 1 Models A and B stop here)					
EEPROM	ID_SD	27	28	ID_SC	EEPROM
5	N/A	29	30	GND	
6	N/A	31	32		12
13	N/A	33	34	GND	
19	N/A	35	36	N/A	16
26	N/A	37	38	Digital IN	20
	GND	39	40	Digital OUT	21

# PUT IT IN A BOX



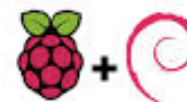
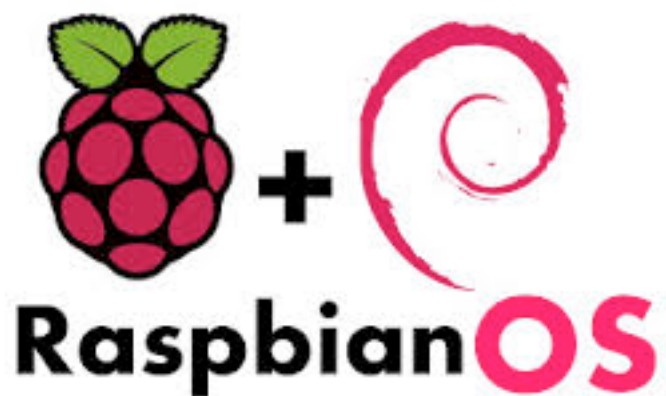
You can have a more integrated version, with a box for outdoor usage and PoE splitter to power the Raspberry with the Ethernet cable. See how we also use a DC-DC converter to get the 5V for the RPI.

# GETTING, COMPILING & INSTALLING THE SOFTWARE



# INSTALLING THE OS

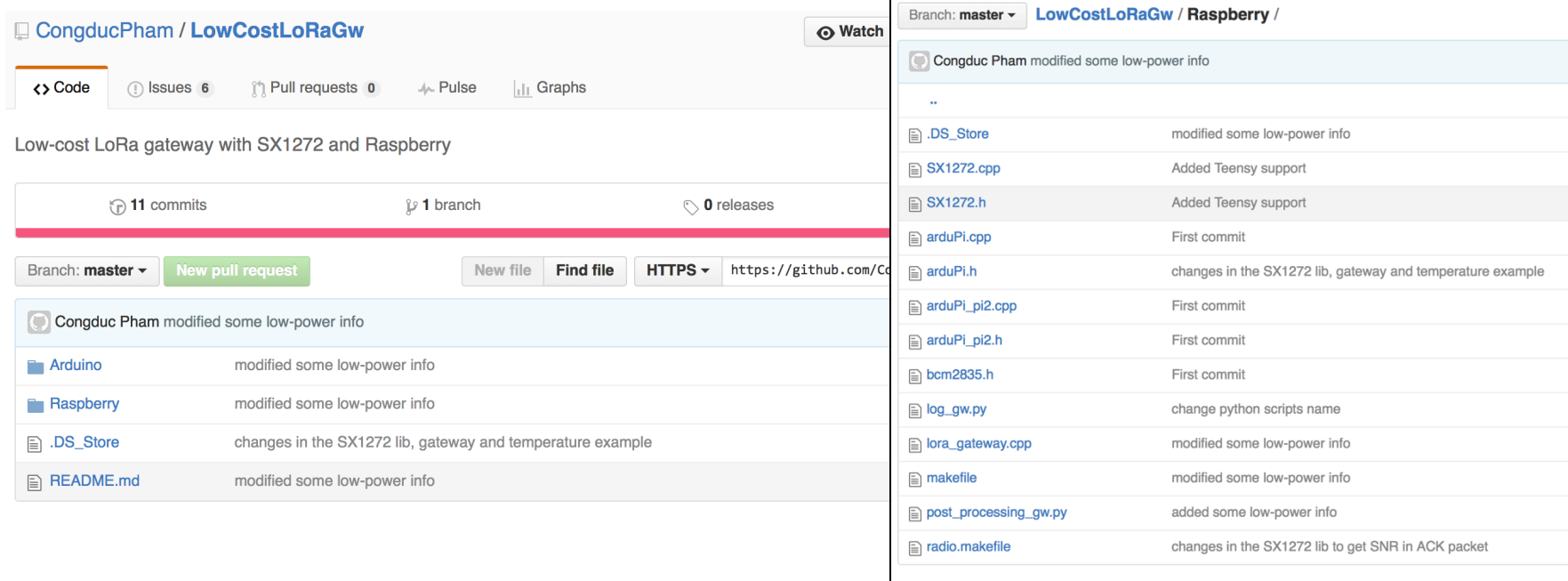
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We use the Raspbian OS. Install it on an SD card. There are many tutorials on the Internet for such procedure. Alternatively, we can provide the full image to burn on the SD card. It's 8GB!



# GETTING THE LoRa SPECIFIC GW SOFTWARE



The screenshot shows the GitHub repository page for CongducPham/LoCostLoRaGw. The repository is described as "Low-cost LoRa gateway with SX1272 and Raspberry". It has 11 commits, 1 branch, and 0 releases. The current branch is master. A commit by Congduc Pham is highlighted, showing changes to several files. A table on the right lists the files and their commit messages.

File	Commit Message
..	..
.DS_Store	modified some low-power info
SX1272.cpp	Added Teensy support
SX1272.h	Added Teensy support
arduinoPi.cpp	First commit
arduinoPi.h	changes in the SX1272 lib, gateway and temperature example
arduinoPi_pi2.cpp	First commit
arduinoPi_pi2.h	First commit
bcm2835.h	First commit
log_gw.py	change python scripts name
lora_gateway.cpp	modified some low-power info
makefile	modified some low-power info
post_processing_gw.py	added some low-power info
radio.makefile	changes in the SX1272 lib to get SNR in ACK packet

```
> mkdir lora_gateway  
> git clone https://github.com/CongducPham/LoCostLoRaGw.git  
> cp LoCostLoRaGw/Raspberry/* lora_gateway/
```

Log in the RPI (ssh) and create a directory called lora\_gateway. Get the LoRa RPI library from our github: <https://github.com/CongducPham/LoCostLoRaGw> (right) then copy all the files of the github's Raspberry folder into the lora\_gateway folder.



# COMPILING THE GW SOFTWARE

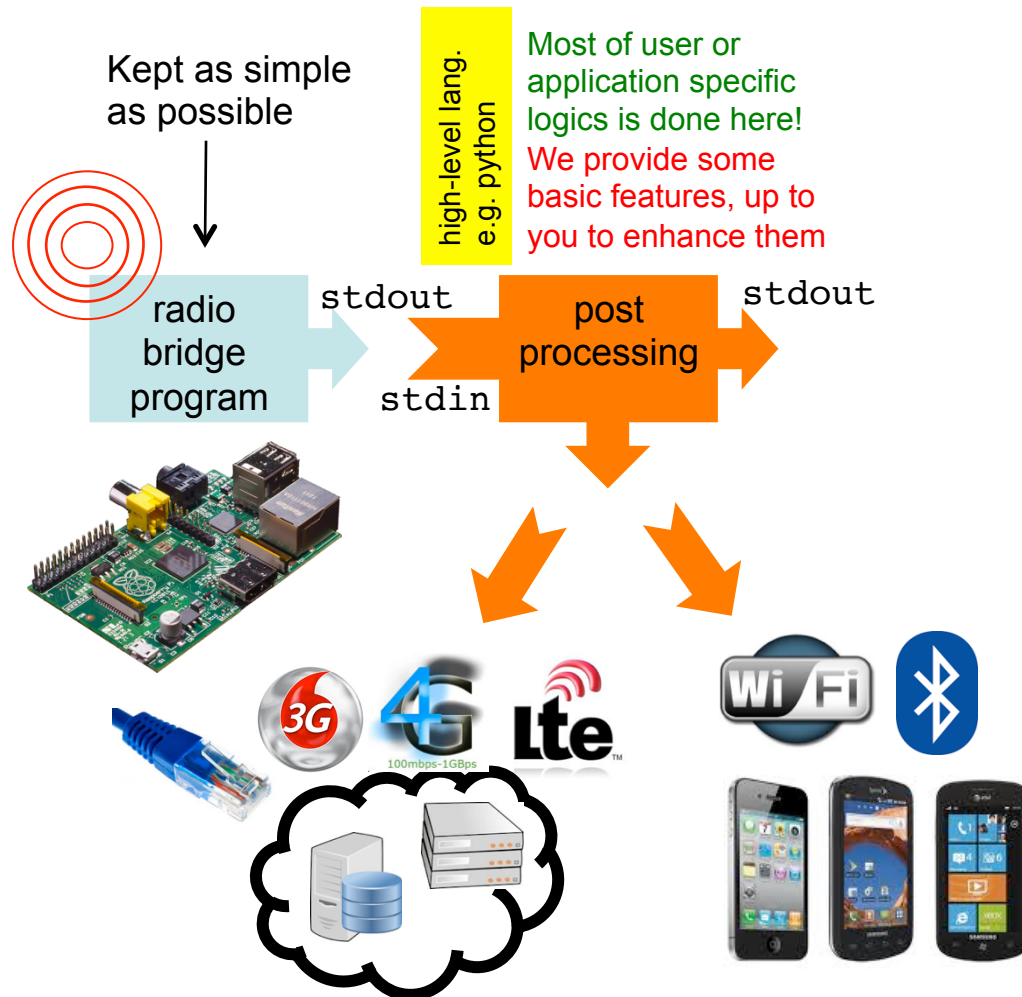
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```
> cd lora_gateway
> make lora_gateway
g++ -DRASPBERRY -DIS_RCV_GATEWAY -c lora_gateway.cpp -o lora_gateway.o
g++ -c arduPi.cpp -o arduPi.o
g++ -c SX1272.cpp -o SX1272.o
g++ -lrt -lpthread lora_gateway.o arduPi.o SX1272.o -o lora_gateway
```

If you have a RPI 2, then type:

```
> make lora_gateway_pi2
```

# OUR LOW-COST GATEWAY ARCHITECTURE

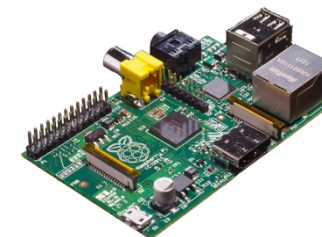


lora\_gateway program

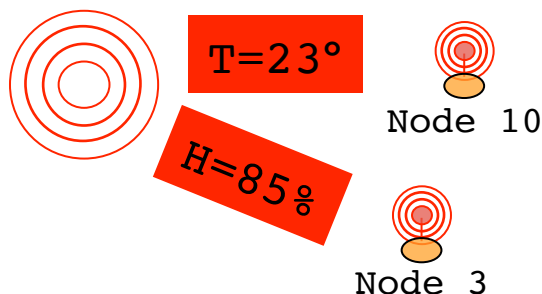
Modified SX1272 lib

ArduPi lib

Raspbian



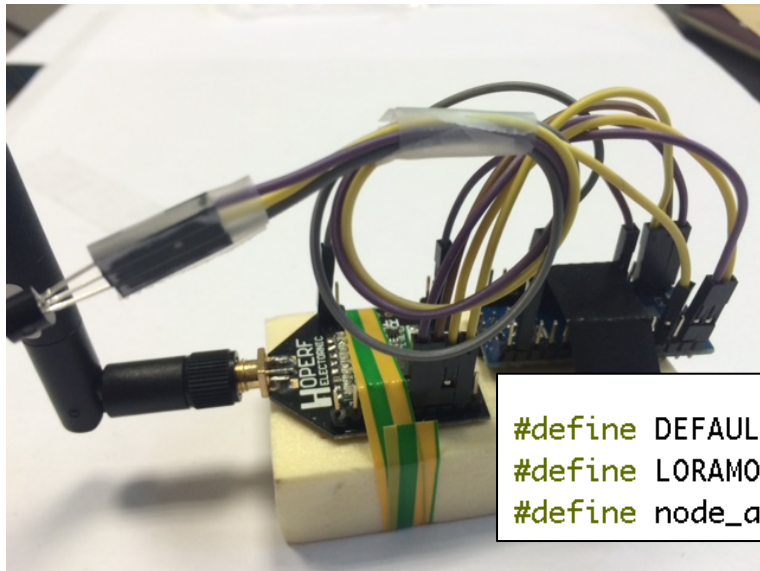
# STARTING THE BASIC GATEWAY



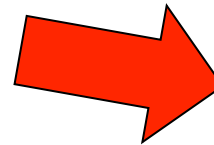
```
> sudo ./lor_gateway
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge

--- rxlor. dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSIpkt=-54
^p1,16,10,0,5,9,-54
T=23°
--- rxlor. dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSIpkt=-54
^p1,16,3,0,5,8,-54
H=85%
```

# DEFAULT CONFIGURATION



\!##18.5



```
#define DEFAULT_DEST_ADDR 1  
#define LORAMODE 4  
#define node_addr 6
```



Device: the default configuration in the Arduino\_LoRa\_temp example is:

- Send packets to the gateway (one or many if in range)

- LoRa mode 4

- Node short address is 6

Gateway: the default configuration of the gateway is:

- LoRa mode 4

- Node short address is 1

# POST-PROCESSING RECEIVED DATA

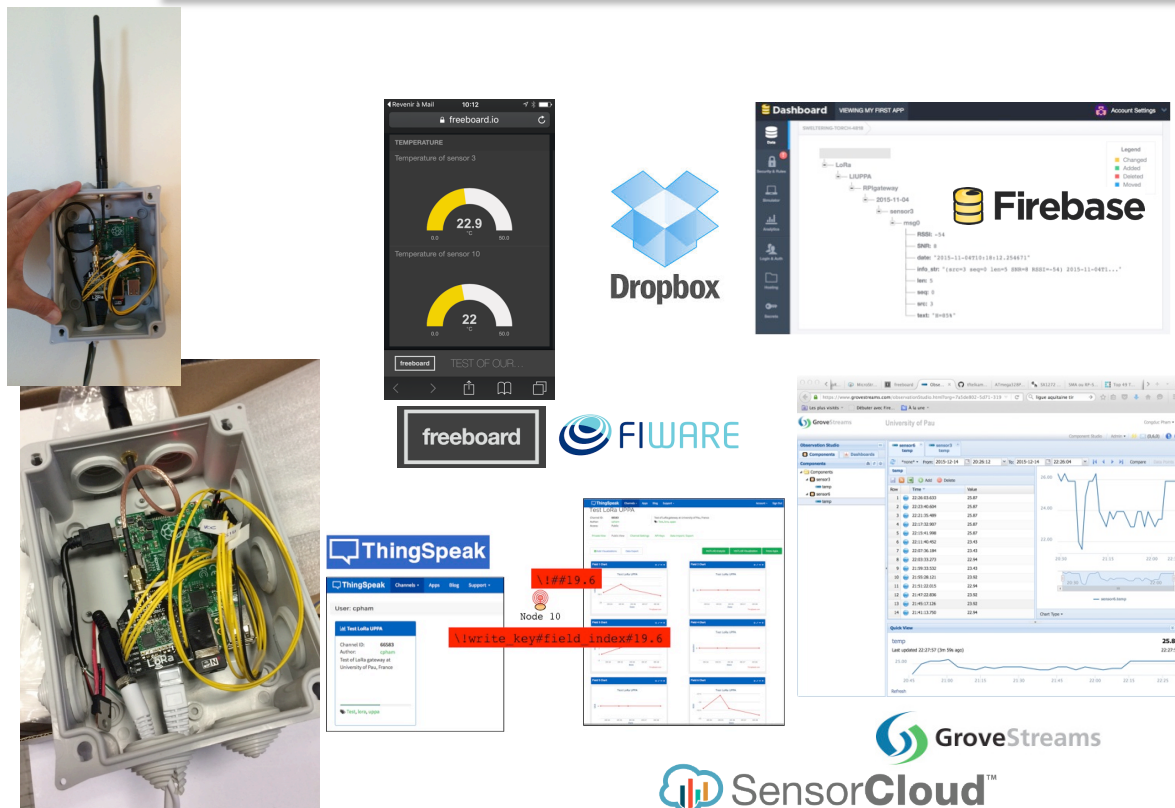
```
> sudo ./lora_gateway | python ./post_processing_gw.py
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge
--- rxlor. dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSIpkt=-54
^p1,16,10,0,5,9,-54
Rcv ctrl packet info 1,16,10,0,5,9,-54
(dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSI=-54)
T=23°
--- rxlor. dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSIpkt=-54
^p1,16,3,0,5,8,-54
Rcv ctrl packet info 1,16,3,0,5,8,-54
(dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSI=-54)
H=85%
```

All lines that are not prefixed by specific character sequence are displayed unchanged

<sup>p</sup> provides information on the last received packet: dst, type, src, seq, len, SNR & RSSI

Pre-defined sequences inserted by the gateway or the end-device allow for information exchanged between the gateway and the post-processing program

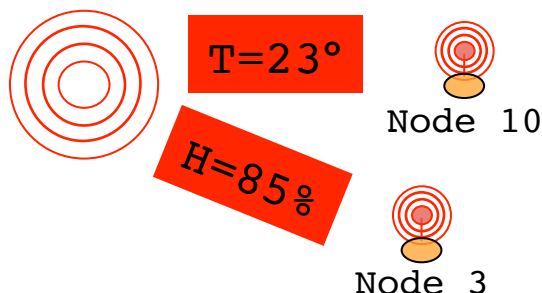
# GATEWAY TO CLOUD



Data received at the gateway can be pushed to IoT clouds. We provide python script examples for many IoT cloud platforms. Most of clouds with REST API can be easily integrated.



# LOG RECEIVED MESSAGES USING CLOUD SERVICES



```
> sudo ./lora_gateway | python ./post_processing_gw.py
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge

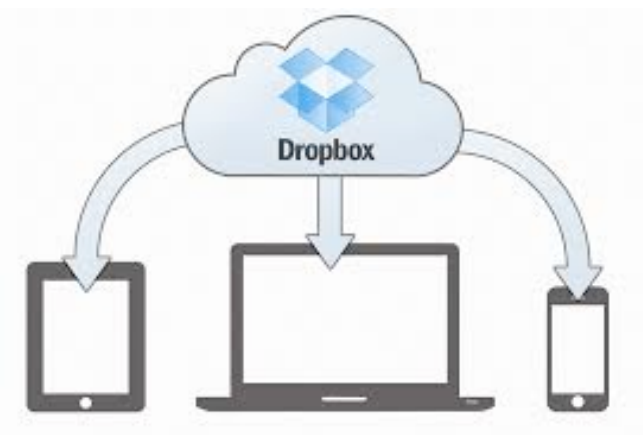
--- rxlor. dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSIpkt=-54
Rcv ctrl packet info 1,16,10,0,5,9,-54
(dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSI=-54)
rcv msg to log (\$) on dropbox : T=23°
--- rxlor. dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSIpkt=-54
Rcv ctrl packet info 1,16,3,0,5,8,-54
(dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSI=-54)
rcv msg to log (\&) on firebase : H=85%
```

\\$ or \& before the data indicates that the data should be logged on a file or server. It is up to the end-device to decide which option

- ❑ A message starting with '\$' is logged in a file 'telemetry.log' in a folder shared through Dropbox


```
(src=10 seq=0 len=5 SNR=9 RSSI=-54) 2015-11-04T10:14:30.328413> T=23°  
(src=10 seq=1 len=7 SNR=8 RSSI=-54) 2015-11-04T10:14:37.443350> T=23.2°  
(src=10 seq=2 len=5 SNR=8 RSSI=-53) 2015-11-04T10:16:23.343657> T=24°  
...
```

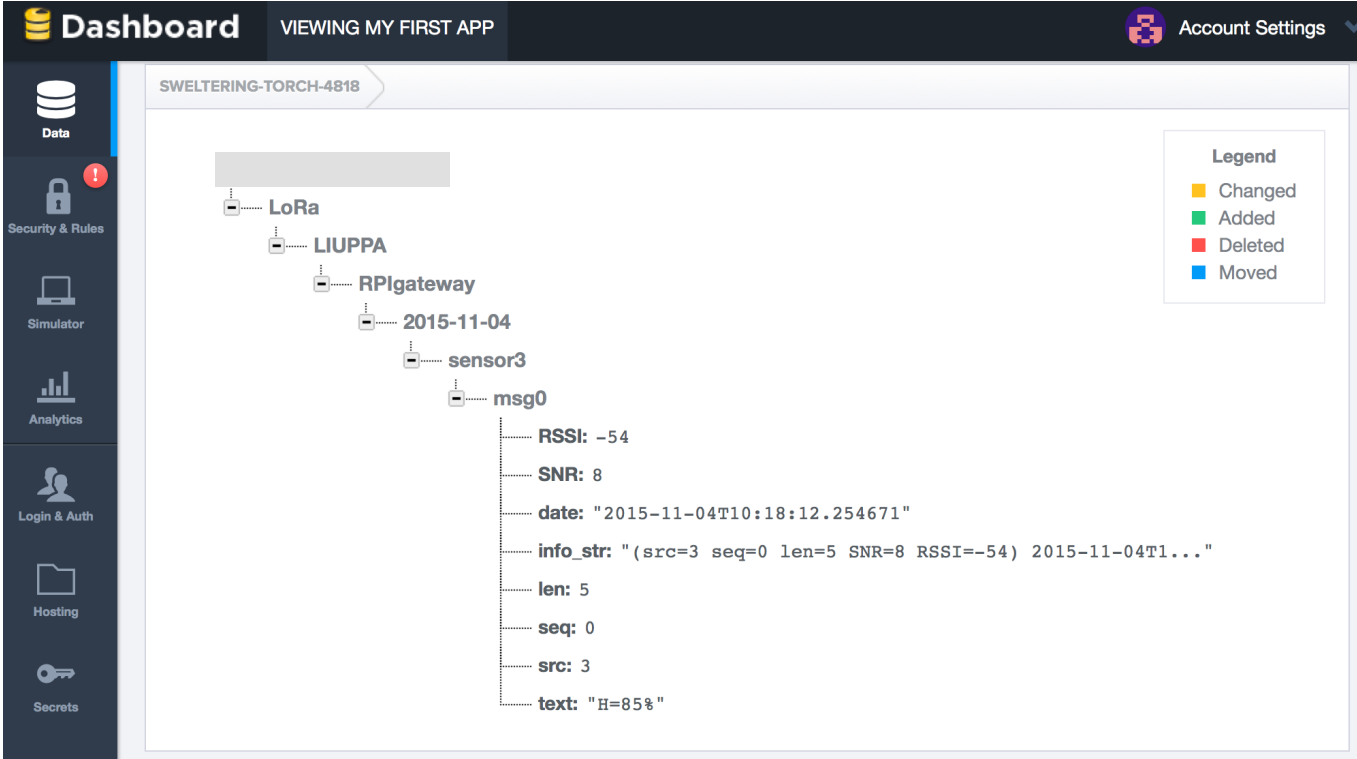
\$T=23°  
Node 10



# USING Firebase

- ❑ A message starting with '`\&`' is logged in a Firebase database

`\&H=85%`   
Node 3



The screenshot shows the Firebase console interface. The top navigation bar includes 'Dashboard', 'VIEWING MY FIRST APP', and 'Account Settings'. The left sidebar contains icons for 'Data', 'Security & Rules', 'Simulator', 'Analytics', 'Login & Auth', 'Hosting', and 'Secrets'. The main content area displays a tree view of the database structure: 'SWELTERING-TORCH-4818' (root) -> 'LoRa' -> 'LIUPPA' -> 'RPIgateway' -> '2015-11-04' -> 'sensor3' -> 'msg0'. The 'msg0' node is expanded, showing a list of message details: 'RSSI: -54', 'SNR: 8', 'date: "2015-11-04T10:18:12.254671"', 'info\_str: "(src=3 seq=0 len=5 SNR=8 RSSI=-54) 2015-11-04T1..."', 'len: 5', 'seq: 0', 'src: 3', and 'text: "H=85%"'. A legend on the right indicates that yellow squares represent 'Changed', green squares represent 'Added', red squares represent 'Deleted', and blue squares represent 'Moved'.

# USING ThingSpeak

- A message starting with '`\!`' is logged in a ThingSpeak channel



ThingSpeak Channels Apps Blog Support

User: cpham

Test LoRa UPPA

Channel ID: 66583

Author: cpham

Test of LoRa gateway at University of Pau, France

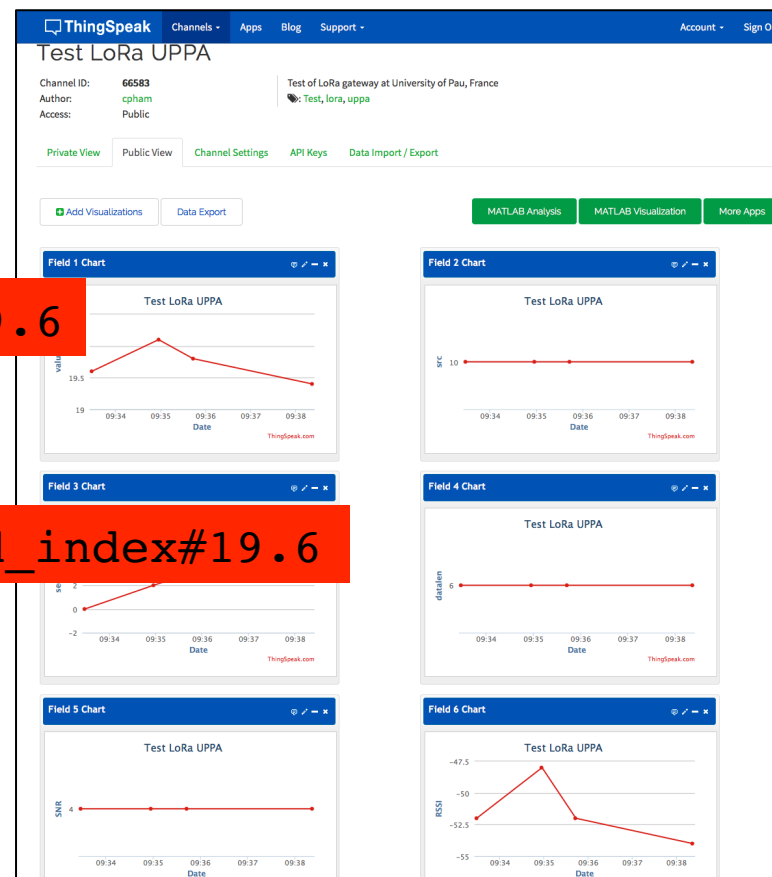
Test, lora, uppa

`\!##19.6`



Node 10

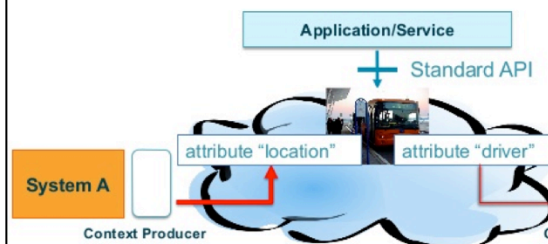
`\!write_key#field_index#19.6`



## FIWARE support has been added with EGM script

### A non-intrusive approach is required

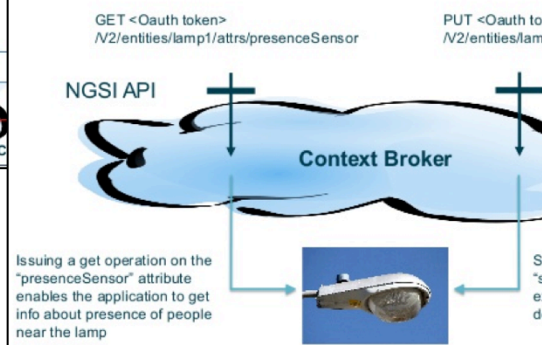
- Capable to integrate with existing or future systems dealing with management of municipal services without impact in their architectures
- Info about attributes of one entity may come from different systems, which work either as Context Producers or Context Consumers
- Applications rely on a single model adapting to system



Figures from FIWARE

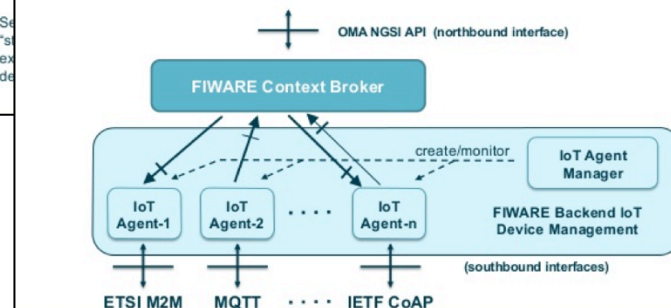
### Connecting to the Internet of Things

- Capturing data from, or Acting upon, IoT devices should be as easy as to read/change the value of attributes linked to context entities



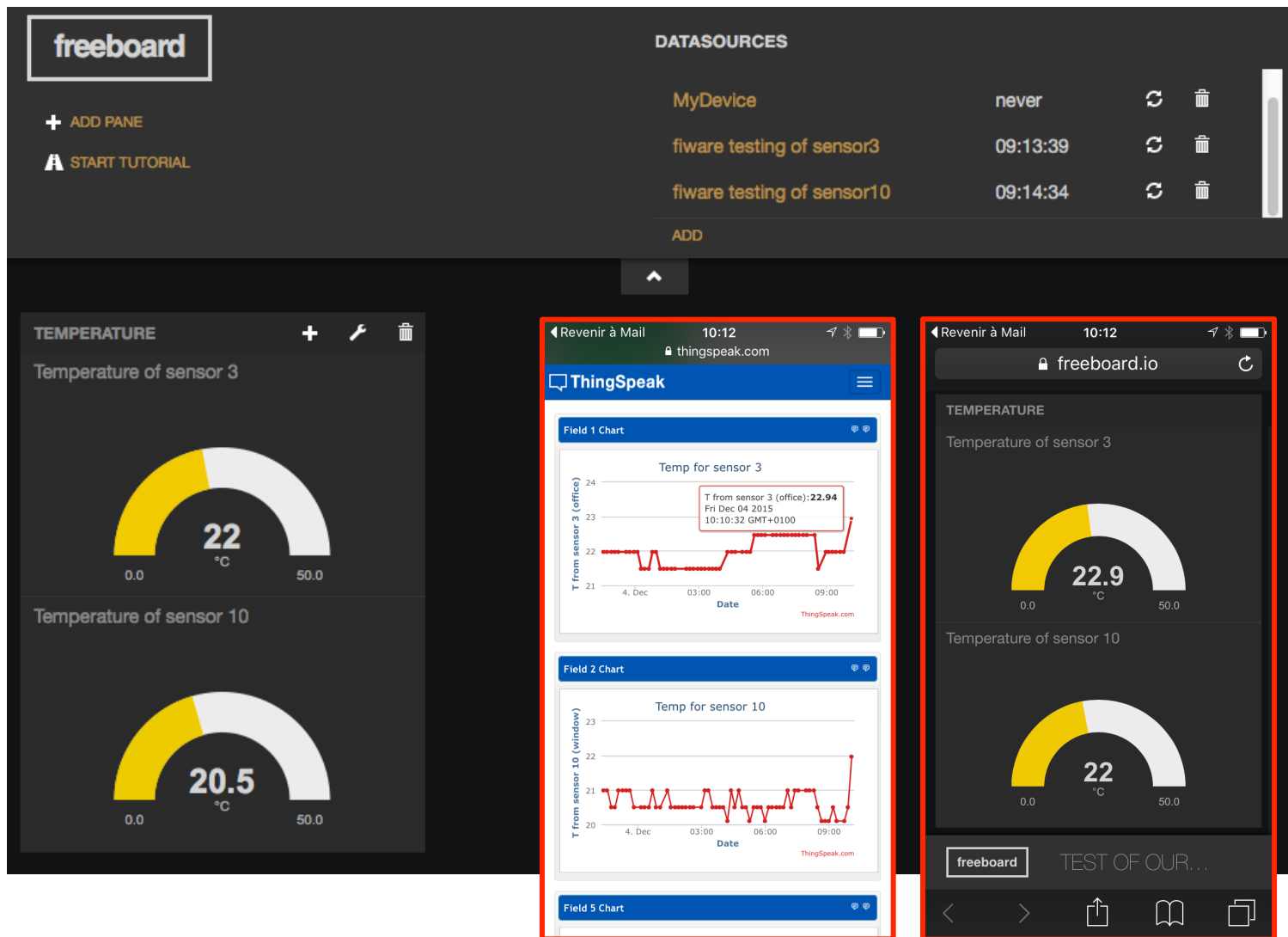
### Integration with sensor networks

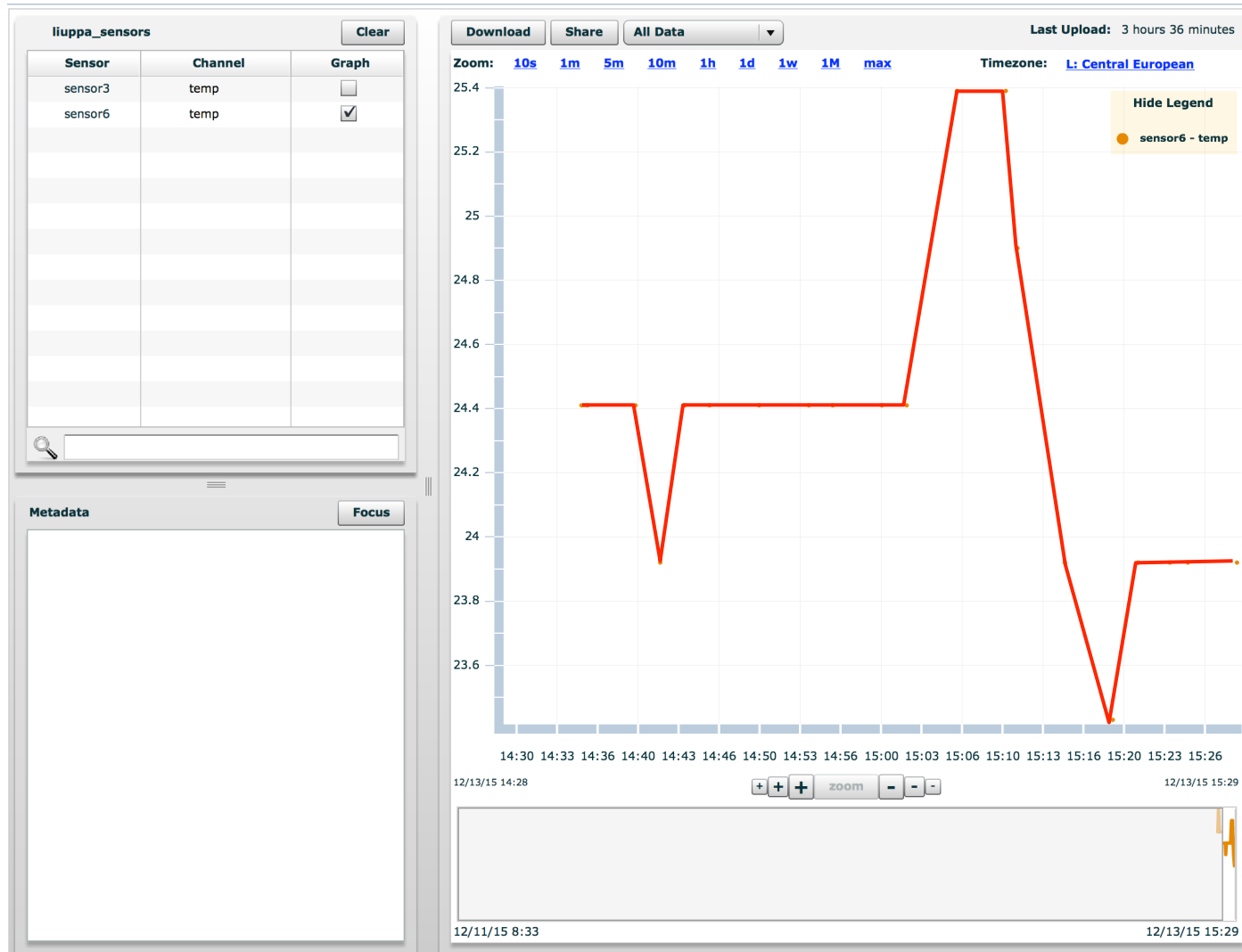
- FIWARE NGSI is capable to deal with the wide variety of IoT protocols today
- Rather than trying to solve the battle of standards at IoT level, it brings a standard where no standard exists today: context information management



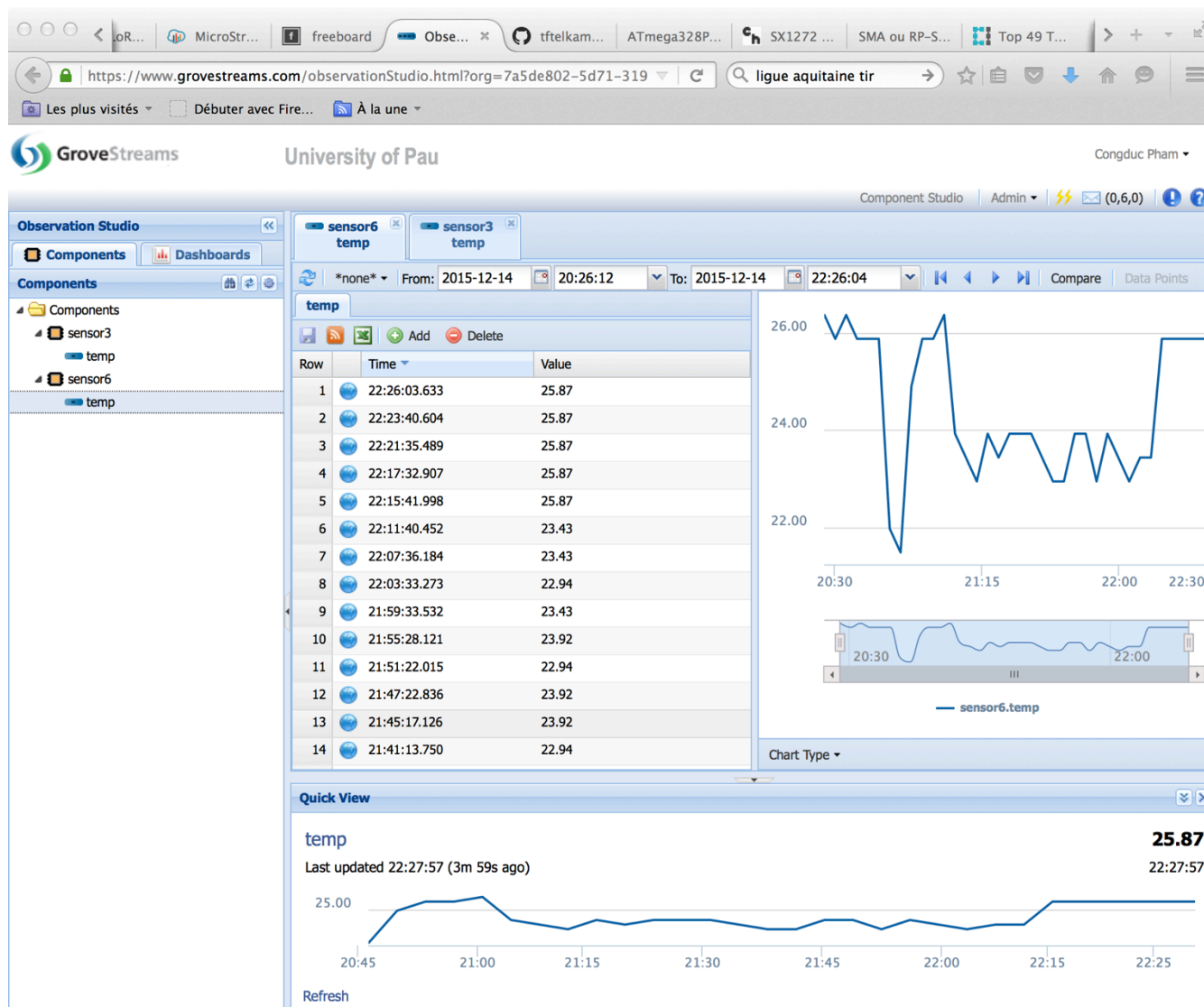


# FREEBOARD IOT CLOUD WITH FIWARE









# ADD A NEW CLOUD

```

if (ch=='\\'):
    now = datetime.datetime.now()

    if _validappkey==1:

        print 'valid app key: accept data'
        ch=sys.stdin.read(1)

        if (ch=='$'): #log on Dropbox

            data = sys.stdin.readline()
            print "rcv msg to log (\$) on dropbox: "+data,
            f=open(os.path.expanduser(_telemetrylog_filename),"a")
            f.write(info_str+' ')
            now = datetime.datetime.now()
            f.write(now.isoformat()+ '> ')
            f.write(data)
            f.close()

        elif (ch=='&' and _firebase==1): #log on Firebase

            data = sys.stdin.readline()
            print 'rcv msg to log (&) on firebase: '+data,
            now = datetime.datetime.now()
            firebase_msg = {
                'dst':dst,

            }

        sensor_entry='sensor%d'% (src)
        msg_entry='msg%d' % (seq)
        date_entry=now.date()
        db_entry = _dbpath+date_entry.isoformat()+ '/' +sensor_entry
        result = _db.put(db_entry, msg_entry, firebase_msg)

    elif (ch=='!' and _thingspeak==1): #log on ThingSpeak

```

Add your own data prefix or replace the default one with your own cloud parameters

# STANDALONE GATEWAY



# RUNNING WITHOUT INTERNET ACCESS

